REMARKS

Referring to the Office Action dated 16 April 2003, claims 1-20 stand rejected. Claim 20 stands rejected under 35 U.S.C. 102e as being anticipated by Shin (US Patent 6,214,116). Claims 1-11, 13, 18 and 19 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Shin in view of Desu (US Patent 5,431,958). Claims 11, 12 and 14-17 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Shin in view of Desu and further in view of Dietze et al. (US Patent 5,685,906).

Applicant respectfully traverses the rejection of claims 1-11, 13, 18, and 19, under 35 U.S.C. 103(a). The cited references, Shin in view of Desu et al., do not include and do not suggest the teachings of Applicant's patent application. The references indicated in the Office Action do not make Applicant's claimed invention obvious.

The Office Action states that

> "Shin teaches a method of providing a process chamber, loading a wafer in a process zone, rotating the wafer, monitoring the temperature of the wafer while it is rotating, flowing a preheated gas over the wafer in a direction parallel to the wafer, inducing a velocity gradient in the direction of the gas flow and maintaining the gas in zones held at preselected temperatures until the gas exits the process chamber, but fails to teach generating a substantially hot wall process zone in the process chamber. Desu et al. teach that cold wall and hot wall processing zones with strip shaped heaters are both well known as equivalents with varying advantages. Using a hot wall chamber rather than the cold wall chamber as Shin apparently suggests has the advantage of conceptual simplicity and high throughput. Thus, it would have been obvious to one skilled in the art at the time of the invention to use a hot wall processing chamber to decrease conceptual complexity and increase throughput."

Applicant is grateful that the Office Action recognizes that Applicant's teachings include using a hot wall processing zone and that Shin teaches using a cold wall processing zone. However, the teachings of Desu et al. are incorrect and misleading; consequently, the office action statement that Applicant's claims 1-11, 13, 18 and 19 are obvious over Shin in view of Desu is incorrect and the rejection should be withdrawn.

A more thorough analysis of the teachings of Desu et al. shows some of their teachings to be incorrect and misleading. In fact, the teachings of Desu et al. are not enabling for producing an isothermal processing zone; consequently, Shin in view of Desu et al. does not support a finding of obviousness for Applicant's claims. Figure 1 of Desu et al. US patent 5,431,958 is a schematic diagram of what Desu et al. identify as being a hot wall MOCVD apparatus used in their invention. Desu et al. referred to the apparatus as a hot wall apparatus although <u>Figure 1 shows that the apparatus is a combination of a hot wall and warm walls</u>. The warm walls are described as a warm temperature zone and are represented in Figure 1 by the dashed lines. The warm temperature zone includes the flow lines for precursors used in the deposition. In column 6 lines 37-41, Desu et al. state that the paths for the precursors are heated at a temperature from 200 degrees C. to 250 degrees C. to prevent the precursors from either condensing or decomposing.

According to Figure 1 of Desu et al. and column 6 lines 17-41, the substrates have a radiated heat transfer view of the furnace walls forming the hot wall and the walls of the warm wall zone. This means that the substrates according to the teachings of Desu et al. are not processed in an isothermal hot wall processing zone; the substrates have a heat transfer view factor of walls having large temperature differences. Not all of the walls of Desu et al. are hot; some of the walls are warm. In the apparatus taught by Desu et al., the substrates experience radiant heat transfer with walls that have temperatures of 200-250 degrees C and walls that have temperatures of 550 degrees C. The wide temperature variations result in temperature gradients in the substrate so

that the wafer is not isothermal. The temperature gradients in the substrate result defects in deposited layers such as epitaxial layers.

Furthermore, the temperature of the precursors is much lower than the deposition temperature. At most, the temperature of the precursors is about 250 degrees C whereas the substrate temperatures are at about 550 degrees C, see Desu et al. column 7, line 33. This means that the precursor gases will cool the substrate and induced further temperature gradients in the substrates. Still further, flowing the significantly cooler precursors over the significantly hotter substrates will induced thermal convection currents over the substrates. This means that the process zone taught by Desu et al. cannot function as an isothermal process zone. Thermal convection does not occur in an isothermal zone.

Actually, the apparatus taught by Desu et al., as being a hot wall reactor, is not a true hot wall reactor and in fact is very similar to the cold wall reactor taught by Desu et al. More specifically, the substrates in the cold wall reactor taught by Desu et al. are heated by physically contacting a hot substrate holder. The wall of the deposition chamber is kept around 250 degrees C as stated in Desu et al. column 6, lines 47-48. The substrate temperature is 600 degrees C as stated in column 8, line 58. This means that the substrates have a view of the cold walls of the reactor for which radiated heat transfer occurs and contributes to temperature gradients in the substrate. The precursors are at a much lower temperature (less than or equal to 250 degrees C) than the substrate temperature. The precursors flow vertically down to the substrate and also induced temperature gradients in the substrate.

In other words, Desu et al. teach a hot wall reactor and a cold wall reactor; both reactors produce significant temperature gradients in the wafer(s) because neither reactor produces isothermal hot wall processing zones. Though the magnitude of the temperature gradients may differ for the reactors taught by Desu et al., significant temperature gradients occur for both. The similarities between the hot wall reactor

taught by Desu et al. and the cold wall reactor taught by Desu et al. are probably the reason why they erroneously conclude there is no significant difference between the performance of their hot wall reactor and their cold wall reactor.

Another possible reason why Desu et al. see essentially the same results for their cold wall reactor as what they see for their hot wall reactor may be that they do not truly know the temperatures of their substrates in either reactor. Figure 2 in the patent to Desu et al. shows a thermocouple for measuring the temperature of the heater in the cold wall reactor for heating the substrate. Desu et al. provide no details about temperature measurements for their hot wall reactor. They do not describe directly measuring the temperature of the substrates. The actual temperature of the substrates for the experiments described by Desu et al. may be much lower than the temperature stated by Desu et al. There is a possibility that the similarity in results for the hot wall reactor taught by Desu et al. and the cold wall reactor taught by Desu et al. are the result of the substrates being very similar in temperature rather than being directly related to whether the process chamber was hot wall or cold wall.

Yet, another possible explanation as to why Desu et al. do not show distinguishing differences between the performance of the hot wall reactor according to Desu et al. and the cold wall reactor according to Desu et al. is that Desu et al. may not have done a detailed comparison of the results for the two reactors. Desu et al. provide 12 figures with data related to films deposited using their hot wall reactor and one figure containing data related to films deposited using their cold wall reactor. Desu et al. provide no quantitative comparison between the films deposited in their hot wall reactor and the films deposited in their cold wall reactor. The only comparison of the films produced in the cold wall reactor are provided in column 9 lines 1-9 where they describe the films produced in the cold wall reactor as being specular on all three different substrates and being single phase with perovskite structure. In column 7 lines 55-65, the films deposited in the hot wall reactor were described as being smooth, which is usually associated with being specular, and being single phase with perovskite structure. In

other words, Desu et al. do not provide sufficient data to be able to determine that there are significant differences between using the hot wall reactor that they teach and the cold wall reactor that they teach.

Shin (column 7 lines 2-5) teaches providing the process gas at about 1000 degrees C and the susceptor temperature controlled at a suitable temperature below 1000 degrees C." Clearly, Shin is not teaching the use of an isothermal process zone. Desu et al. teach providing the precursors, the gases, at temperatures that are about 300 degrees C. cooler than the substrate temperature. Combining the teachings of Shin with the teachings of Desu et al. do not result in teaching providing the gases at a temperature about equal to that of the substrate so as to maintain an isothermal process zone. Shin and Desu et al. both ignore the temperature variations caused by providing the gases at temperatures significantly different from the substrate temperature. More specifically for Desu et al., the disclosure of Desu et al. is not enabling for providing a hot wall reactor and fails further to provide an isothermal hot wall reactor. Desu et al. teach using a process zone that includes a hot wall and warm walls and Desu et al. teach providing the gases at temperatures hundreds of degrees different from the temperatures in the process zone. Although Desu et al. referred to their apparatus as a hot wall reactor, the reactor does not produce an isothermal hot wall process zone and their teachings are not enabling for an isothermal process zone as taught by Applicant.

In contrast to Shin in view of Desu et al., Claim 1 of Applicant's patent application is an independent claim that sets forth a method for thermally processing a semiconductor wafer. In one embodiment, the method comprises the steps of:

a. providing a process chamber;
b. generating a substantially isothermal hot wall process zone in the process chamber using substantially isothermal sections of electrical resistance strip heaters;
c. loading the wafer in the process zone;
d. rotating the wafer;

e. flowing a preheated gas over the wafer in a direction substantially parallel to the wafer surface;
f. inducing a velocity gradient in the preheated gas so that the velocity of the gas increases in the direction of the gas flow; and
g. maintaining the gas in zones held at preselected temperatures until the gas exits the process chamber.

In other words, Applicant's method claim describes the use of an isothermal hot wall process zone, substrate rotation, and a gas velocity gradient for processing the substrate. Shin teaches an apparatus capable of producing substrate rotation, a gas velocity gradient, and substrate heating. Desu et al. teach an apparatus having a process zone that includes a hot wall and warm walls; Desu et al. do not provide an enabling disclosure for an isothermal hot wall process zone as taught by Applicant. Shin and Desu et al. both teach providing process gases to the process zone where the temperature of the process gases is significantly different from that of the substrate temperature, in some cases a difference of hundreds of degrees C.

Applicant's teachings differ from that of Shin in view of Desu by also teaching the use of an isothermal hot wall process zone; Shin in view of Desu et al. does not teach the use of an isothermal hot wall process zone because Desu et al. do not provide an enabling disclosure for an isothermal hot wall process zone. The results that can be obtained with Applicant's teachings differ from the results that can be obtained using the teachings of Shin in view of Desu et al. In fact, the configuration of Shin's apparatus in view of Desu et al. cannot be used to practice Applicant's teachings; it would be necessary to redesign Shin's apparatus in ways that are not disclosed and are not enabled by the teachings of Desu et al. This means that the apparatus and corresponding method of Shin in view of Desu et al. are different from that of Applicant's teachings. In addition, Applicant's teachings would not be obvious to one of ordinary skill in the art over Shin in view of Desu et al.

Shin in view of Desu et al. disclose an apparatus that is not capable of providing the process temperature conditions of an isothermal hot wall process zone. Because of the

absence of hot wall isothermal process conditions, the apparatus of Shin in view of Desu et al. does not include the functionality taught by Applicant's invention and neither do the corresponding method steps. Shin in view of Desu et al. does not teach the use of a substantially isothermal hot wall process zone because Desu et al. teach using an apparatus that has a process zone including a hot wall and warm walls and does not provide an enabling disclosure for an isothermal hot wall processing zone. In other words, the teachings of Shin in view of Desu et al. do not describe and do not suggest the teachings of Applicant's invention. As such, withdrawal of the 35 U.S.C. 103(a) rejection of independent claim 1 is respectfully requested.

Claim 8 of Applicant's patent application is an independent claim that sets forth a method. In one embodiment, the method involves the steps of:

a) providing a process chamber;
b) enclosing the process chamber in a substantially cold-wall housing;
c) generating a substantially isothermal hot wall process zone in the process chamber using substantially isothermal sections of electrical resistance strip heaters and measuring temperatures at multiple locations on at least one of heaters and wall of the process chamber to control the temperature of the process zone;
d) restricting heat loss from the heaters and process chamber;
e) loading the wafer into the process zone;
f) rotating the wafer;
g) monitoring the temperature of the wafer by measuring the temperature at multiple locations on the wafer while the wafer is rotating;
h) flowing a preheated gas over the wafer in a direction substantially parallel to the wafer surface;
i) inducing a velocity gradient in the preheated gas so that the velocity of the gas increases in the direction of the gas flow;
j) capturing substantially all process gas leakage from the process chamber; and

k) maintaining the gas in zones held at preselected temperatures until the gas exits the process chamber.

Please note that step c of Applicant's claim 8 recites "generating a substantially isothermal hot wall process zone." In other words, step c) of Applicant's independent claim 8 distinguishes Applicant's teachings from that of Shin in view of Desu et al. in the same manner that Applicant's claim 1 distinguishes over the teachings of Shin in view of Desu et al. Shin in view of Desu et al. does not teach and does not suggest the use of a substantially isothermal hot wall process zone because Desu et al. teach using an apparatus that has a process zone including a hot wall and warm walls and does not provide an enabling disclosure for a hot wall processing zone nor an isothermal hot wall processing zone. In other words, the teachings of Shin in view of Desu et al. do not describe and do not suggest the teachings of Applicant's invention. As such, withdrawal of the 35 U.S.C. 103(a) rejection of independent claim 8 is respectfully requested.

Claim 9 of Applicant's patent application is an independent claim that sets forth a combination of method steps. In one embodiment, the method involves the steps of:

a) containing a wafer in a substantially isothermal process zone;
b) rotating the wafer within the process zone;
c) monitoring the temperature of the wafer while the wafer is rotating;
d) flowing a preheated gas over the wafer in the process zone in a direction substantially parallel to the wafer surface;
e) inducing a velocity gradient in the preheated gas so that the velocity of the gas increases in the direction of the gas flow as the gas passes over the wafer.

Please note that step a) of Applicant's claim 9 recites "containing a wafer in a substantially isothermal process zone." In other words, step a) of Applicant's independent claim 9 distinguishes Applicant's teachings from that of Shin in view of Desu et al. in the same manner that Applicant's claim 1 and claim 8 distinguish over the teachings of Shin in view of Desu et al. Shin does not teach and does not suggest the use of a substantially isothermal process zone; Desu et al. do not provide an enabling disclosure for an isothermal process zone. Shin and Desu et al., either

alone or in combination, describe a non-isothermal process zone in which it is expected that the substrate temperature, the gas temperature in the process zone, and the temperature of the walls of the process zone are different, i.e., not isothermal. The teachings of Desu et al. are not enabling for producing an isothermal process zone. The teachings of Shin in view of Desu et al. do not describe and do not suggest to a person of ordinary skill in the art the teachings of Applicant. As such, withdrawal of the 35 U.S.C. 103(a) rejection of independent claim 9 is respectfully requested.

Applicant respectfully traverses the rejection of claims 11, 12, and 14-17 under 35 U.S.C. 103(a). The cited references do not include and do not suggest the teachings of Applicant's patent application. The references indicated in the office action do not make Applicant's claimed invention obvious.

The arguments presented supra for withdrawal of the 35 USC 103(a) rejections of independent claims 1, 8, and 9 show that Applicant's invention is not obvious over Shin in view of Desu et al. because Applicant's teachings distinguish over the teachings of Shin in view of Desu et al. Since Shin in view of Desu et al. does not teach Applicant's invention, it is inappropriate to reject Applicant's claims 11, 12, and 14-17 under 35 USC 103(a) as being unpatentable over Shin in view of Desu et al. and further in view of Dietze et al. (US Patent 5,685,906) because the teachings of Dietze et al. which includes supplying a gas containing silicon to deposit silicon does not describe and does not suggest Applicant's invention as presented in claims 11, 12, and 14-17. In other words, Applicant's invention is not obvious because Applicant's claims distinguish over Shin in view of Desu et al. and adding the teachings of Dietze et al. does not provide the additional teachings needed to be equivalent to or suggestive of Applicant's teachings. More specifically, Dietze et al. only adds the teachings of depositing silicon and does not add teachings of using an isothermal process zone or the teachings of using an isothermal hot wall process zone to the teachings of Shin in view of Desu et al. as would be needed to anticipate and make Applicant's invention obvious.

The teachings of Shin in view of Desu et al. and further in view of Dietze et al. abide by the "then-accepted wisdom in the art," whereas, Applicant's teachings were non-obvious and unrealized by anyone of ordinary skill in the art. Based on Shin, the accepted wisdom at the time of Applicant's invention was to allow a more limited operability and lower performance because of failure to use teachings such as an isothermal process zone and other limitations recited in Applicant's claims. Consequently, further justification for the withdrawal of the rejection under 35 U.S.C. 103(a) becomes apparent upon applying the standards set out in the Manual of Patent Examining Procedures, section 2141.01 III, which states:

> "It is difficult but necessary that the decision maker forget what he or she has been taught... about the claimed invention and cast the mind back to the time the invention was made..., to occupy the mind of one skilled in the art who is presented only with the references, and who is normally guided by the then accepted wisdom in the art."

In light of the above remarks, withdrawal of the rejection of claims 11, 12, and 14-17 under 35 U.S.C 103(a) is respectfully requested.

Applicant respectfully traverses the rejection of claim 20 under 35 U.S.C. 102(e). The cited reference, Shin, does not include and does not suggest the teachings of Applicant's patent application. The reference indicated in the Office Action does not anticipate Applicant's claimed invention.

Claim 20 of Applicant's patent application is an independent method claim for thermally processing a wafer using step plus function language. In one embodiment, the method involves:

a) step for maintaining the wafer at a substantially isothermal temperature;
b) step for rotating the wafer for improved heat and mass transfer uniformity;
c) step for inducing a gas flow having a velocity gradient above the surface of the wafer for improved heat and mass transfer uniformity for the surface of the wafer;

d) step for controlling the temperature of the gas so as to reduce the amount of cooling of the wafer by the gas; and

e) step for controlling the temperature of the gas so as to substantially prevent deposition of non-adherent layers that cause particle contamination of the wafer.

Please note that step a) of Applicant's claim 20 recites, "step for maintaining the wafer at a substantially isothermal temperature." Since step a) of Applicant's claim 20 uses step plus function language, Applicant respectfully requests reconsideration of claim 20 under the rules of the Manual of Patent Examination Procedures Section 2181, Identifying a 35 U.S.C. 112, Sixth Paragraph Limitation [R-1] which states

> "... in Donaldson, the Federal Circuit stated:
> Per our holding, the "broadest reasonable interpretation" that an examiner may give means-plus-function language is that statutorily mandated in paragraph six. Accordingly, the PTO may not disregard the structure disclosed in the specification corresponding to such language when rendering a patentability determination."

Applicant's specification provides one or more descriptions for each of the means plus function claim elements of claim 20 for one or more embodiments of Applicant's invention.

As seen in Applicant's remarks, supra, about Applicant's claims 1, 8, and 9, Applicant's teachings are different from that of Shin and Applicant's teachings are not anticipated by Shin. Applicant's specification teaches using an isothermal process zone in embodiments presented therein. Shin does not teach the use of an isothermal process zone. <u>As stated in the Office Action dated 16 April 2003, Shin fails to teach generating a substantially hot wall process zone in the process chamber.</u> In other words, Shin describes a non-isothermal process zone in which it is expected that the substrate temperature, the gas temperature in the process zone, and the temperature of the walls of the process zone are different, i.e., not isothermal. Shin's teachings are not

conducive to or are incapable of maintaining the wafer at a substantially isothermal temperature. However, using an isothermal process zone as taught by Applicant is highly conducive to maintaining the wafer at a substantially isothermal temperature. As such, withdrawal of the 35 U.S.C. 102e rejection of independent claim 20 is respectfully requested.

Again, Applicant provides additional support for the novelty and non-obviousness of Applicant's invention that can be seen in recent experimental data collected using an embodiment of Applicant's invention. Test results for the embodiment show silicon deposition rates of 3.8 micrometers per minute using $SiHCl_3$ at 1070 degrees C. However, in a cold wall reactor, a temperature of 1170 degrees C is believed required. Applicant believes that the higher rate at lower temperature is an effect of using a hot wall process chamber so that the surface of the wafer is not radiating to a cold wall. This embodiment of Applicant's isothermal process zone reduces crystal slip for epitaxial silicon deposition. This means silicon deposited according to Applicant's teachings has a higher degree of crystalline quality at higher deposition rates at lower temperatures than is expected for cold wall reactors. Applicant believes that analogous results cannot be obtained using the teachings of Shin, the teachings of Shin in view of Desu et al., nor the teachings of Shin in view of Desu et al. and further in view of Dietze et al.

Based on the experimental results presented above for one embodiment of Applicant's invention, it is shown that Applicant's teachings can produce improved crystalline quality in addition to higher throughput at reduced temperature. This means that Applicant's teachings can provide, for some applications, unexpected benefits of improved crystalline quality under more favorable conditions. Applicant's teachings provide more than decreased conceptual complexity and increased throughput so that it would not have been obvious to one skilled in the art.

Applicant has shown that independent claims 1, 8, and 9 describe embodiments of Applicant's invention that are not described and not suggested by Shin in view of Desu et al. In addition, Applicant has shown that independent claims 1, 8, and 9 describe embodiments of Applicant's invention that are not described and not suggested by Shin in view Desu et al. and further in view of Dietz et al. in combination with the knowledge of one of ordinary skill in the art. Applicant has shown that independent claim 20 describes embodiments of Applicant's invention that are not described and not suggested by Shin. As such, withdrawal of the rejections of independent claims 1, 8, and 9 under 35 U.S.C. 103(a) and claim 20 under 35 U.S.C. 102e and withdrawal of the rejections of dependent claims 11, 12, and 14-17 under 35 U.S.C. 103(a) are respectfully requested. Upon withdrawal of the rejections of independent claims 1, 8, and 9, Applicant respectfully requests withdrawal of the rejections of dependent claims 2-7, 10, 13, 18, and 19 as they now depend from allowable independent claims 1, 8, and 9 and add further limitations and/or further description.

In view of the foregoing remarks, further and favorable action in the form of a notice of allowance for all 20 of the submitted claims is believed to be next in order, and such action is earnestly solicited.

Please telephone the undersigned at (408) 396-1112 if there are any questions regarding this matter.

Respectfully submitted,

Larry Williams
Reg. No. 39,428
3645 Montgomery Dr.
Santa Rosa, CA 95405-5212
Customer No. 25199